WHAT IS CLAIMED IS:

1. A method for analyzing a computed tomography scan of a whole lung for lung nodules, said method comprising the steps of:

(a) segmenting a first lung region and a second lung region from the computed tomography scan, the first lung region corresponding to lung parenchyma of the lung and the second lung region corresponding to at least one of a pleural surface of the lung and a surface defined by vessels within the lung;

(b) generating an initial list of nodule candidates from the computed tomography scan within the first lung region, the list including at least a center location and an estimated size associated with each nodule candidate;

(c) generating a subimage for each nodule candidate in the initial list;

(d) selectively removing streaking artifacts from the subimage; and

(e) filtering the nodule candidate identified on the initial list to eliminate false positives from the list.

2. A method for analyzing a whole lung computed tomography scan as defined in Claim 1, wherein step (b) comprises the substeps of:

(i) thresholding the first lung region;

(ii) labeling high density voxels foreground voxels to identify nodule candidate regions;

(iii) determining for each foreground voxel RMI;

(iv) selecting the local maximum $\hat{R}_{MI}$ within a nodule candidate region;

(v) determining a limited extent criterion for each foreground voxel which corresponds to a $\hat{R}_{MI}$;

(vi) generating the initial list of nodule candidates which satisfy the limited extent criterion, the list including at least Nc and $\hat{R}_{MI}$ associated with the corresponding foreground voxel.

3. A method for analyzing a whole lung computed tomography scan as defined in Claim1, wherein step (d) comprises the substeps of:

(i) determining an amount of streaking artifact present in the sub-image; and

(ii) filtering the streaking artifact out from the subimage when the amount of the streaking artifact present in the sub-image exceeds T_{sar}.

4. A method for analyzing a whole lung computed tomography scan as defined in Claim 3, wherein the amount of streaking artifact present in the sub-image is calculated by a metric

$$S_m = \frac{1}{nmp}\sum_{i}^{n}\sum_{j}^{m}\sum_{k}^{p}\left((I(i,j,k) - I(i,j+1,k)\right)^2$$

5. A method for analyzing a whole lung computed tomography scan as defined in Claim 3, wherein the filtering is performed by a vertical median filter of size 1x3.

6. A method for analyzing a whole lung computed tomography scan as defined in Claim 3, wherein T_{sar} is from about 20000 to about 80000.

7. A method for analyzing a whole lung computed tomography scan as defined in Claim 1, wherein step (e) comprises the substeps of:

(i) determining for each nodule candidate a fraction, F_a, a surface of the nodule candidate that is attached to other solid structures; and

(ii) removing the nodule candidate from the list when the fraction exceeds T_a.

8. A method for analyzing a whole lung computed tomography scan as defined in Claim 1, wherein step (e) comprises the substeps of:

(i) generating a cube wall about each nodule candidate;

(ii) determining an intersection volume, V_{ni}, corresponding to portions of the nodule region associated with the nodule candidate that intersect the cube wall;

(ii) removing the nodule candidate from the list when the fraction of the intersection volume, V_{ni}, over the volume of the nodule candidate, V_n, exceeds T_{vv}.

9. A method for analyzing a whole lung computed tomography scan as defined in Claim 7, wherein step (e) comprises the substeps of:

(i) generating a cube wall about each nodule candidate;

(ii) determining an intersection volume, V_{ni}, corresponding to portions of the nodule region associated with the nodule candidate that intersect the cube wall;

(ii) removing the nodule candidate from the list when the fraction of the intersection volume, V_{ni}, over the volume of the nodule candidate, V_n, exceeds T_{vv}.

10. A lung nodule detecting apparatus for analyzing a computed tomography scan of a whole lung for lung nodules, the lung nodule detecting apparatus comprising:

a detecting unit configured to:

(a) segment a first lung region and a second lung region from the computed tomography scan, the first lung region corresponding to lung parenchyma

of the lung and the second lung region corresponding to at least one of a pleural surface of the lung and a surface defined by vessels within the lung;

(b) generate an initial list of nodule candidates from the computed tomography scan within the first lung region, the list including at least a center location and an estimated size associated with each nodule candidate;

(c) generate a subimage for each nodule candidate in the initial list;

(d) selectively remove streaking artifacts from the subimage; and

(e) filter the nodule candidate identified on the initial list to eliminate false positives from the list.

11. A lung nodule detecting apparatus as defined by Claim 10, wherein for step (b) said detecting unit is configured to:

(i) threshold the first lung region;

(ii) label high density voxels foreground voxels to identify nodule candidate regions;

(iii) determine for each foreground voxel *RMI*;

(iv) select the local maximum $\hat{R}_{MI}$ within a nodule candidate region;

(v) determine a limited extent criterion for each foreground voxel which corresponds to a $\hat{R}_{MI}$;

(vi) generate the initial list of nodule candidates which satisfy the limited extent criterion, the list including at least N_c and $\hat{R}_{MI}$ associated with the corresponding foreground voxel.

12. A lung nodule detecting apparatus as defined by Claim 10, wherein step (d) comprises the substeps of:

(i) determine an amount of streaking artifact present in the sub-image; and

(ii) filter the streaking artifact out from the subimage when the amount of the streaking artifact present in the sub-image exceeds T_{sar}.

13. A lung nodule detecting apparatus as defined by Claim 12, wherein the amount of streaking artifact present in the sub-image is calculated by a metric

$$S_m = \frac{1}{nmp} \sum_{i}^{n} \sum_{j}^{m} \sum_{k}^{p} \left((I(i,j,k) - I(i,j+1,k) \right)^2$$

14. A lung nodule detecting apparatus as defined by Claim 12, further comprising a vertical median filter of size 1x3 to filter the streaking artifact.

15. A lung nodule detecting apparatus as defined by Claim 12, wherein T_{sar} is from about 20000 to about 80000.

16. A lung nodule detecting apparatus as defined by Claim 10, wherein step (e) comprises the substeps of:

(i) determining for each nodule candidate a fraction, Fa, a surface of the nodule candidate that is attached to other solid structures; and

(ii) removing the nodule candidate from the list when the fraction exceeds Ta.

17. A lung nodule detecting apparatus as defined by Claim 10, wherein step (e) comprises the substeps of:

(i) generating a cube wall about each nodule candidate;

(ii) determining an intersection volume, V_{ni}, corresponding to portions of the nodule region associated with the nodule candidate that intersect the cube wall;

(ii) removing the nodule candidate from the list when the fraction of the intersection volume, V_{ni}, over the volume of the nodule candidate, V_n, exceeds T_{vv}.

18. A lung nodule detecting apparatus as defined by Claim 16, wherein step (e) comprises the substeps of:

(i) generating a cube wall about each nodule candidate;

(ii) determining an intersection volume, V_{ni}, corresponding to portions of the nodule region associated with the nodule candidate that intersect the cube wall;

(ii) removing the nodule candidate from the list when the fraction of the intersection volume, V_{ni}, over the volume of the nodule candidate, V_n, exceeds T_{vv}.

19. An article of manufacture for detecting lung nodules in a computed tomography scan of a whole lung, the article comprising:

a machine readable medium containing one or more programs which when executed implement the steps of:

(a) segmenting a first lung region and a second lung region from the computed tomography scan, the first lung region corresponding to lung parenchyma of the lung and the second lung region corresponding to at least one of a pleural surface of the lung and a surface defined by vessels within the lung;

(b) generating an initial list of nodule candidates from the computed tomography scan within the first lung region, the list including at least a center location and an estimated size associated with each nodule candidate;

(c) generating a subimage for each nodule candidate in the initial list;

(d) selectively removing streaking artifacts from the subimage; and

(e) filtering the nodule candidate identified on the initial list to eliminate false positives from the list.

20. An article of manufacture for detecting lung nodules as defined by Claim 19, wherein step (b) comprises the substeps of:

(i) thresholding the first lung region;

(ii) labeling high density voxels foreground voxels to identify nodule candidate regions;

(iii) determining for each foreground voxel RMI;

(iv) selecting the local maximum $\hat{R}_{MI}$ within a nodule candidate region;

(v) determining a limited extent criterion for each foreground voxel which corresponds to a $\hat{R}_{MI}$;

(vi) generating the initial list of nodule candidates which satisfy the limited extent criterion, the list including at least N_c and $\hat{R}_{MI}$ associated with the corresponding foreground voxel.

21. An article of manufacture for detecting lung nodules as defined by Claim 19, wherein step (d) comprises the substeps of:

(i) determining an amount of streaking artifact present in the sub-image; and

(ii) filtering the streaking artifact out from the subimage when the amount of the streaking artifact present in the sub-image exceeds T_{sar}.

22. An article of manufacture for detecting lung nodules as defined by Claim 21, wherein the amount of streaking artifact present in the sub-image is calculated by a metric

$$S_m = \frac{1}{nmp}\sum_{i}^{n}\sum_{j}^{m}\sum_{k}^{p}(\,(I(i,j,k) - I(i,j+1,k))^2$$

23. An article of manufacture for detecting lung nodules as defined by Claim 21, wherein the filtering is performed by a vertical median filter of size 1x3.

24. An article of manufacture for detecting lung nodules as defined by Claim 21, wherein T_{sar} is from about 20000 to about 80000.

25. An article of manufacture for detecting lung nodules as defined by Claim 19, wherein step (e) comprises the substeps of:

(i) determining for each nodule candidate a fraction, F_a, a surface of the nodule candidate that is attached to other solid structures; and

(ii) removing the nodule candidate from the list when the fraction exceeds T_a.

26. An article of manufacture for detecting lung nodules as defined by Claim 19, wherein step (e) comprises the substeps of:

(i) generating a cube wall about each nodule candidate;

(ii) determining an intersection volume, V_{ni}, corresponding to portions of the nodule region associated with the nodule candidate that intersect the cube wall;

(ii) removing the nodule candidate from the list when the fraction of the intersection volume, V_{ni}, over the volume of the nodule candidate, Vn, exceeds T_{vv}.

27. An article of manufacture for detecting lung nodules as defined by Claim 25, wherein step (e) comprises the substeps of:

(i) generating a cube wall about each nodule candidate;

(ii) determining an intersection volume, V_{ni}, corresponding to portions of the nodule region associated with the nodule candidate that intersect the cube wall;

(ii) removing the nodule candidate from the list when the fraction of the intersection volume, V_{ni}, over the volume of the nodule candidate, V_n, exceeds T_{vv}.

28. A method for correlating a segmentation of 3-d images of a pulmonary nodule from a high-resolution computed tomography (CT) scans, the images being in a floating point pixel-format associated with a 6-dimensional parameter space and including a first image (im_1) obtained at time-1 and a second image (im_2) obtained at time-2, the method comprising the steps of:

(a) selecting a first region-of-interest (ROI_1) for the nodule in the first image (im_1);

(b) selecting a second region-of-interest (ROI_2) for the nodule in the second image (im_2);

(c) registering the second region-of-interest (ROI_2) to the first region-of-interest (ROI_1) to obtain a transformed second region-of-interest (ROI_{2t});

(d) separately segmenting both the nodule in the first region-of-interest (ROI_1) and the transformed second region-of-interest (ROI_{2t}); and

(e) adjusting the first segmented nodule (S_1) and the second segmented nodule (S_2).

29. A method for correlating a segmentation of 3-d images as defined in Claim 28, wherein the first region-of-interest (ROI_1) is cubic and is selected to be about three times the size of the diameter of the nodule.

30. A method for correlating a segmentation of 3-d images as defined in Claim 28, wherein the second region-of-interest (ROI_2) is cubic and is selected to be about three times the size of the diameter of the nodule.

31. A method for correlating a segmentation of 3-d images as defined in Claim 28, wherein step (d) includes at least one of the following substeps of:

(i) gray-level thresholding;

(ii) morphological filtering for vessel removal: and

(iii) plane clipping for separarting a pleural wall.

32. A method for correlating a segmentation of 3-d images as defined in Claim 31, wherein the gray-level thresholding is performed at an adaptive threshold level.

33. A method for correlating a segmentation of 3-d images as defined in Claim 32, wherein the adaptive threshold level is selected for each region-of-interest (ROI_1 and ROI_2) by:

determining a peak parenchyma value, v_p;

determining a peak nodule value, v_n;

calculating the adaptive threshold level as a midpoint between the peak parenchyma value, v_p, and the peak nodule value, v_n.

34. A method for correlating a segmentation of 3-d images as defined in Claim 33, further comprising the step of calculating an intensity histogram, $H(x)$ for determining the peak parenchyma value, v_p, and the peak nodule value, v_n.

35. A method for correlating a segmentation of 3-d images as defined in Claim 34, wherein the intensity histogram, $H(x)$, is calculated between about -1024 HU and about 476 HU with a bin size of about 1.

36. A method for correlating a segmentation of 3-d images as defined in Claim 34, further comprising the substep of:

filtering the intensity histogram, $H(x)$, with a gaussian with standard deviation of about 25 HU prior to determining the peak parenchyma value, v_p, and the peak nodule value, v_n.

37. A method for correlating a segmentation of 3-d images as defined in Claim 34, wherein the intensity histogram, $H(x)$, is searched between about -1024 HU and about -680 for the peak parenchyma value, v_p.

38. A method for correlating a segmentation of 3-d images as defined in Claim 34, wherein the intensity histogram, $H(x)$, is searched between about -227 HU and about -173 for the peak nodule value, v_n.

39. A method for correlating a segmentation of 3-d images as defined in Claim 28, wherein registering the second region-of-interest (ROI_2) to the first region-of-interest (ROI_1) to obtain a transformed second region-of-interest (ROI_{2t}) comprises the substeps of:

(a) calculating initial rigid-body transformation parameters for a rigid-body transformation on the second region-of-interest (ROI_2);

(b) determining the optimum rigid-body transformation parameters by calculating a registration metric between the first region-of-interest (ROI_1) and the rigid-body transformation on the second region-of-interest (ROI_2); and

(c) generating a registered image from the optimum rigid-body transformation parameters.

40. A method for correlating a segmentation of 3-d images as defined in Claim 39, wherein the registration metric is calculated by

transforming the second region-of-interest (ROI_2) with the initial rigid-body transformation parameters to obtain a transformed second region-of-interest (ROI_{2t});

calculating the registration metric as a mean-squared-difference (MSD) between the transformed second region-of-interest (ROI_{2t}) and the first region-of-interest (ROI_1); and

searching for the minimum mean-squared-difference (MSD) in the 6-dimensional parameter space.

41. A method for correlating a segmentation of 3-d images as defined in Claim 40, wherein the transforming of the second region-of-interest (ROI_2) to obtain the transformed second region-of-interest (ROI_{2t}) is a mapping of a point v in 3-d space to a point v' in transformed space defined by :

$$v' = R_x R_y R_z v + \begin{bmatrix} t_x \\ t_y \\ t_z \end{bmatrix}$$

wherein R_x, R_y, and R_z are rotation matrices defined as:

$$R_x = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(r_x) & -\sin(r_x) \\ 0 & \sin(r_x) & \cos(r_x) \end{bmatrix}$$

$$R_y = \begin{bmatrix} \cos(r_y) & 0 & \sin(r_y) \\ 0 & 1 & 0 \\ -\sin(r_y) & 0 & \cos(r_y) \end{bmatrix}$$

$$R_z = \begin{bmatrix} \cos(r_z) & -\sin(r_z) & 0 \\ \sin(r_z) & \cos(r_z) & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

42. A method for correlating a segmentation of 3-d images as defined in Claim 39, wherein said initial rigid-body transformation parameters include six parameters (*tx,ty,tz,rx,ry,rz*) respectively defined as translation in x, translation in y, translation in z, rotation about the x-axis, rotation about the y-axis, and rotation about the z-axis;

wherein the initial rotation parameters (*rx,ry,rz*) are all set to zero; and the initial translation parameters (*tx,ty,tz,*) are set so that the nodule in the first region-of-interest (ROI_1) overlaps the nodule in the second region-of-interest (ROI_2)) during the initial calculation of the registration metric.

43. A method for correlating a segmentation of 3-d images as defined in Claim 40, wherein the mean-squared-difference (MSD) is gaussian weighted.

44. A method for correlating a segmentation of 3-d images as defined in Claim 31, wherein:

a first thresholded image (T_1)and a second thresholded image (T_2) are defined by gray-level thresholding prior to vessel removal and separating the pleural wall; and

step (e) is performed by comparing the segmented nodules and the thresholded images.

45. A method for correlating a segmentation of 3-d images as defined in Claim 44, wherein an active pixel is marked as one of:

a repeat nodule pixel;

a nodule growth pixel;

a nodule atrophy pixel; and

a nodule missegmentation pixel.

46. A method for correlating a segmentation of 3-d images as defined in Claim 44, wherein a foreground pixel in the first segmented nodule (S_1) is marked as a repeated nodule pixel from the first region-of-interest (ROI_1) to the transformed second region-of-interest (ROI_{2t}) when the corresponding pixel in second segmented nodule (S_2) and the corresponding pixel in second thresholded image (T_2) are both foreground

47. A method for correlating a segmentation of 3-d images as defined in Claim 45, wherein a foreground pixel in the first segmented nodule (S_1) is marked as a nodule atrophy pixel when the corresponding pixel in second segmented nodule (S_2) is background and the corresponding pixel in second thresholded image (T_2) is background.

48. A method for correlating a segmentation of 3-d images as defined in Claim 45, wherein a foreground pixel in the first segmented nodule (S_1) is marked as a missegmented pixel in the first region-of-interest (ROI_1) when the corresponding pixel in second segmented nodule (S_2) is background and the corresponding pixel in second thresholded image (T_2) is foreground.

49. A method for correlating a segmentation of 3-d images as defined in Claim 45, wherein a foreground pixel in the second segmented nodule (S_2) is marked as a repeated nodule pixel from the first region-of-interest (ROI_1) to the transformed second region-of-interest (ROI_{2t}) when the corresponding pixel in first segmented nodule (S_1) and the corresponding pixel in first thresholded image (T_1) are both foreground.

50. A method for correlating a segmentation of 3-d images as defined in Claim 45, wherein a foreground pixel in the second segmented nodule (S_2) is marked as a nodule growth pixel when the corresponding pixel in first segmented nodule (S_1) is background and the corresponding pixel in first thresholded image (T_1) is background.

51. A method for correlating a segmentation of 3-d images as defined in Claim 45, wherein a foreground pixel in the second segmented nodule (S_2) is marked as a missegmented pixel in the transformed second region-of-interest (ROI_{2t}) when the corresponding pixel in first segmented nodule (S_1) is background and the corresponding pixel in first thresholded image (T_1) is foreground.

52. A registration apparatus for correlating a segmentation of 3-d images of a pulmonary nodule from a high-resolution computed tomography (CT) scans, the images being in a floating point pixel-format associated with a 6-dimensional parameter space and including a first image (im_1) obtained at time-1 and a second image (im_2) obtained at time-2, the registration apparatus comprising:

a registration unit configured to:

(a) select a first region-of-interest (ROI_1) for the nodule in the first image (im_1);

(b) select a second region-of-interest (ROI_2) for the nodule in the second image (im_2);

(c) register the second region-of-interest (ROI_2) to the first region-of-interest (ROI_1) to obtain a transformed second region-of-interest (ROI_{2t});

(d) separately segment both the nodule in the first region-of-interest (ROI_1) and the transformed second region-of-interest (ROI_{2t}); and

(e) adjust the first segmented nodule (S_1) and the second segmented nodule (S_2).

53. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 52, wherein the first region-of-interest (ROI_1) is cubic and is selected to be about three times the size of the diameter of the nodule.

54. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 52, wherein the second region-of-interest (ROI_2) is cubic and is selected to be about three times the size of the diameter of the nodule.

55. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 52, wherein for step (d) said registration unit is configured to:

(i) gray-level threshold;

(ii) morphological filter to remove vessels; and

(iii) plane clip to separate a pleural wall.

56. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 55, wherein the gray-level threshold is performed at an adaptive threshold level.

57. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 56, wherein the adaptive threshold level is selected for each region-of-interest (ROI_1 and ROI_2) by:

determining a peak parenchyma value, v_p;

determining a peak nodule value, v_n;

calculating the adaptive threshold level as a midpoint between the peak parenchyma value, v_p, and the peak nodule value, v_n.

58. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 57, wherein said registration unit is configured to calculate an

intensity histogram, $H(x)$ for determining the peak parenchyma value, v_p, and the peak nodule value, v_n.

59. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 58, wherein the intensity histogram, $H(x)$, is calculated between about -1024 HU and about 476 HU with a bin size of about 1.

60. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 58, wherein said registration unit is configured to filter the intensity histogram, $H(x)$, with a gaussian with standard deviation of about 25 HU prior to determining the peak parenchyma value, v_p, and the peak nodule value, v_n.

61. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 58, wherein the intensity histogram, $H(x)$, is searched between about -1024 HU and about -680 for the peak parenchyma value, v_p.

62. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 58, wherein the intensity histogram, $H(x)$, is searched between about -227 HU and about -173 for the peak nodule value, v_n.

63. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 52, wherein said registration unit is configured to:

(a) calculate initial rigid-body transformation parameters for a rigid-body transformation on the second region-of-interest (ROI_2);

(b) determine the optimum rigid-body transformation parameters by calculating a registration metric between the first region-of-interest (ROI_1) and the rigid-body transformation on the second region-of-interest (ROI_2); and

(c) generate a registered image from the optimum rigid-body transformation parameters.

64. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 63, wherein the registration metric is calculated by

transforming the second region-of-interest (ROI_2) with the initial rigid-body transformation parameters to obtain a transformed second region-of-interest (ROI_{2t}));

calculating the registration metric as a mean-squared-difference (MSD) between the transformed second region-of-interest (ROI_{2t}) and the first region-of-interest (ROI_1); and

searching for the minimum mean-squared-difference (MSD) in the 6-dimensional parameter space.

65. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 64, wherein the transforming of the second region-of-interest (ROI_2) to obtain the transformed second region-of-interest (ROI_{2t}) is a mapping of a point v in 3-d space to a point v' in transformed space defined by :

$$v' = R_x R_y R_z v + \begin{bmatrix} t_x \\ t_y \\ t_z \end{bmatrix}$$

wherein R_x, R_y, and R_z are rotation matrices defined as:

$$R_x = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(r_x) & -\sin(r_x) \\ 0 & \sin(r_x) & \cos(r_x) \end{bmatrix}$$

$$R_y = \begin{bmatrix} \cos(r_y) & 0 & \sin(r_y) \\ 0 & 1 & 0 \\ -\sin(r_y) & 0 & \cos(r_y) \end{bmatrix}$$

$$R_z = \begin{bmatrix} \cos(r_z) & -\sin(r_z) & 0 \\ \sin(r_z) & \cos(r_z) & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

66. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 63, wherein said initial rigid-body transformation parameters include six parameters (tx,ty,tz,rx,ry,rz) respectively defined as translation in x, translation in y, translation in z, rotation about the x-axis, rotation about the y-axis, and rotation about the z-axis;

wherein the initial rotation parameters (rx,ry,rz) are all set to zero; and the initial translation parameters $(tx,ty,tz,)$ are set so that the nodule in the first region-of-interest (ROI_1) overlaps the nodule in the second region-of-interest (ROI_2)) during the initial calculation of the registration metric.

67. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 64, wherein the mean-squared-difference (MSD) is gaussian weighted.

68. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 55, wherein:

a first thresholded image (T_1)and a second thresholded image (T_2) are defined by gray-level thresholding prior to vessel removal and separating the pleural wall; and

step (e) is performed by comparing the segmented nodules and the thresholded images.

69. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 68, wherein an active pixel is marked as one of:

a repeat nodule pixel;

a nodule growth pixel;

a nodule atrophy pixel; and

a nodule missegmentation pixel.

70. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 69, wherein a foreground pixel in the first segmented nodule (S_1) is marked as a repeated nodule pixel from the first region-of-interest (ROI_1) to the transformed second region-of-interest (ROI_{2t}) when the corresponding pixel in second segmented nodule (S_2) and the corresponding pixel in second thresholded image (T_2) are both foreground

71. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 69, wherein a foreground pixel in the first segmented nodule (S_1) is marked as a nodule atrophy pixel when the corresponding pixel in second segmented nodule (S_2) is background and the corresponding pixel in second thresholded image (T_2) is background.

72. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 69, wherein a foreground pixel in the first segmented nodule (S_1) is marked as a missegmented pixel in the first region-of-interest (ROI_1) when the corresponding pixel in second segmented nodule (S_2) is background and the corresponding pixel in second thresholded image (T_2) is foreground.

73. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 69, wherein a foreground pixel in the second segmented nodule (S_2) is marked as a repeated nodule pixel from the first region-of-interest (ROI_1) to the transformed second region-of-interest (ROI_{2t}) when the corresponding pixel in first segmented nodule (S_1) and the corresponding pixel in first thresholded image (T_1) are both foreground.

74. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 69, wherein a foreground pixel in the second segmented nodule (S_2) is marked as a nodule growth pixel when the corresponding pixel in first segmented nodule (S_1) is background and the corresponding pixel in first thresholded image (T_1) is background.

75. A registration apparatus for correlating a segmentation of 3-d images as defined in Claim 69, wherein a foreground pixel in the second segmented nodule (S_2) is marked as a missegmented pixel in the transformed second region-of-interest (ROI_{2t}) when the corresponding pixel in first segmented nodule (S_1) is background and the corresponding pixel in first thresholded image (T_1) is foreground.

76. An article of manufacture for correlating a segmentation of 3-d images of a pulmonary nodule from a high-resolution computed tomography (CT) scans, the images being in a floating point pixel-format associated with a 6-dimensional parameter space and including a first image (im_1) obtained at time-1 and a second image (im_2) obtained at time-2, the article comprising:

a machine readable medium containing one or more programs which when executed implement the steps of:

(a) selecting a first region-of-interest (ROI_1) for the nodule in the first image (im_1);

(b) selecting a second region-of-interest (ROI_2) for the nodule in the second image (im_2);

(c) registering the second region-of-interest (ROI_2) to the first region-of-interest (ROI_1) to obtain a transformed second region-of-interest (ROI_{2t});

(d) separately segmenting both the nodule in the first region-of-interest (ROI_1) and the transformed second region-of-interest (ROI_{2t}); and

(e) adjusting the first segmented nodule (S_1) and the second segmented nodule (S_2).

77. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 76, wherein the first region-of-interest (ROI_1) is cubic and is selected to be about three times the size of the diameter of the nodule.

78. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 76, wherein the second region-of-interest (ROI_2) is cubic and is selected to be about three times the size of the diameter of the nodule.

79. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 76, wherein step (d) includes at least one of the following substeps of:

(i) gray-level thresholding;

(ii) morphological filtering for vessel removal: and

(iii) plane clipping for separarting a pleural wall.

80. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 79, wherein the gray-level thresholding is performed at an adaptive threshold level.

81. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 80, wherein the adaptive threshold level is selected for each region-of-interest (ROI_1 and ROI_2) by:

determining a peak parenchyma value, v_p;

determining a peak nodule value, v_n;

calculating the adaptive threshold level as a midpoint between the peak parenchyma value, v_p, and the peak nodule value, v_n.

82. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 81, further comprising the step of calculating an intensity histogram, $H(x)$ for determining the peak parenchyma value, v_p, and the peak nodule value, v_n.

83. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 82, wherein the intensity histogram, $H(x)$, is calculated between about -1024 HU and about 476 HU with a bin size of about 1.

84. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 82, further comprising the substep of:

filtering the intensity histogram, $H(x)$, with a gaussian with standard deviation of about 25 HU prior to determining the peak parenchyma value, v_p, and the peak nodule value, v_n.

85. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 82, wherein the intensity histogram, $H(x)$, is searched between about -1024 HU and about -680 for the peak parenchyma value, v_p.

86. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 82, wherein the intensity histogram, $H(x)$, is searched between about -227 HU and about -173 for the peak nodule value, v_n.

87. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 76, wherein registering the second region-of-interest (ROI_2) to the first region-of-interest (ROI_1) to obtain a transformed second region-of-interest (ROI_{2t}) comprises the substeps of:

(a) calculating initial rigid-body transformation parameters for a rigid-body transformation on the second region-of-interest (ROI_2);

(b) determining the optimum rigid-body transformation parameters by calculating a registration metric between the first region-of-interest (ROI_1) and the rigid-body transformation on the second region-of-interest (ROI_2); and

(c) generating a registered image from the optimum rigid-body transformation parameters.

88. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 87, wherein the registration metric is calculated by

transforming the second region-of-interest (ROI_2) with the initial rigid-body transformation parameters to obtain a transformed second region-of-interest (ROI_{2t}));

calculating the registration metric as a mean-squared-difference (MSD) between the transformed second region-of-interest (ROI_{2t}) and the first region-of-interest (ROI_1); and

searching for the minimum mean-squared-difference (MSD) in the 6-dimensional parameter space.

89. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 88, wherein the transforming of the second region-of-interest (ROI_2) to obtain the transformed second region-of-interest (ROI_{2t}) is a mapping of a point v in 3-d space to a point v' in transformed space defined by :

$$v' = R_x R_y R_z v + \begin{bmatrix} t_x \\ t_y \\ t_z \end{bmatrix}$$

wherein R_x, R_y, and R_z are rotation matrices defined as:

$$R_x = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(r_x) & -\sin(r_x) \\ 0 & \sin(r_x) & \cos(r_x) \end{bmatrix}$$

$$R_y = \begin{bmatrix} \cos(r_y) & 0 & \sin(r_y) \\ 0 & 1 & 0 \\ -\sin(r_y) & 0 & \cos(r_y) \end{bmatrix}$$

$$R_z = \begin{bmatrix} \cos(r_z) & -\sin(r_z) & 0 \\ \sin(r_z) & \cos(r_z) & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

90. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 87, wherein said initial rigid-body transformation parameters include six parameters (*tx,ty,tz,rx,ry,rz*) respectively defined as translation in x, translation in y, translation in z, rotation about the x-axis, rotation about the y-axis, and rotation about the z-axis;

wherein the initial rotation parameters (*rx,ry,rz*) are all set to zero; and the initial translation parameters (*tx,ty,tz,*) are set so that the nodule in the first region-of-interest (ROI_1) overlaps the nodule in the second region-of-interest (ROI_2)) during the initial calculation of the registration metric.

91. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 88, wherein the mean-squared-difference (MSD) is gaussian weighted.

92. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 79, wherein:

a first thresholded image (T_1)and a second thresholded image (T_2) are defined by gray-level thresholding prior to vessel removal and separating the pleural wall; and

step (e) is performed by comparing the segmented nodules and the thresholded images.

93. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 92, wherein an active pixel is marked as one of:

a repeat nodule pixel;

a nodule growth pixel;

a nodule atrophy pixel; and

a nodule missegmentation pixel.

94. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 93, wherein a foreground pixel in the first segmented nodule (S_1) is marked as a repeated nodule pixel from the first region-of-interest (ROI_1) to the transformed second region-of-interest (ROI_{2t}) when the corresponding pixel in second segmented nodule (S_2) and the corresponding pixel in second thresholded image (T_2) are both foreground

95. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 93, wherein a foreground pixel in the first segmented nodule (S_1) is marked as a nodule atrophy pixel when the corresponding pixel in second segmented nodule (S_2) is background and the corresponding pixel in second thresholded image (T_2) is background.

96. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 93, wherein a foreground pixel in the first segmented nodule (S_1) is marked as a missegmented pixel in the first region-of-interest (ROI_1) when the corresponding pixel in second segmented nodule (S_2) is background and the corresponding pixel in second thresholded image (T_2) is foreground.

97. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 93, wherein a foreground pixel in the second segmented nodule (S_2) is marked as a repeated nodule pixel from the first region-of-interest (ROI_1) to the transformed second region-of-interest (ROI_{2t}) when the corresponding pixel in first segmented nodule (S_1) and the corresponding pixel in first thresholded image (T_1) are both foreground.

98. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 93, wherein a foreground pixel in the second segmented nodule (S_2) is marked as a nodule growth pixel when the corresponding pixel in first segmented nodule (S_1) is background and the corresponding pixel in first thresholded image (T_1) is background.

99. An article of manufacture for correlating a segmentation of 3-d images as defined in Claim 93, wherein a foreground pixel in the second segmented nodule (S_2) is marked as a missegmented pixel in the transformed second region-of-interest (ROI_{2t}) when the corresponding pixel in first segmented nodule (S_1) is background and the corresponding pixel in first thresholded image (T_1) is foreground.